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(54) Wear resistant material

(57) A wear resistant material comprises a mixture of from 20 to 80% by weight of a resiliently deformable polymer, such as polyurethane, and from 80 to 20% of a particulate material of hardness greater than 4 on the Moh scale. The particulate material may be concentrated at a surface of the material.

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WEAR RESISTANT MATERIAL

The invention concerns a wear resistant material and particularly, although not exclusively, a material which may be used to protect, for example, the surfaces of machine components and the inner walls of processing plant vessels, pipes and chutes against damage by abrasive materials.

Resilient polymeric materials such as polyurethane and rubber have been used to line pipes for transporting abrasive fluids but it has been found that large particles present in the fluids tend to cut the lining causing premature failure.

According to the present invention there is provided a wear resistant material which comprises a mixture of from 20 to 80% by weight of a resiliently deformable polymer and from 80 to 20% by weight of a particulate material of hardness greater than 4 as measured on the Moh scale.

The effect of the particulate material is to increase the stiffness of the lining and to improve its resistance to damage by large abrasive particles. The resulting material is thus of greater rigidity and resistance to wear by abrasion than polymer materials which have hitherto been used in protective linings and coatings.

In a preferred embodiment, the particulate material is not distributed evenly throughout the polymer, but is concentrated at a surface of the material which, in use of an article made from the material, is subjected to abrasion.

The material may consist substantially entirely of the polymer and the particulate material. The material may comprises more than 40% by weight of the material. Preferably, the material comprises 40% to 60% by weight of the polymer, at least in the region adjacent the surface which, in use, is subjected to abrasion.

The resiliently deformable polymer is preferably polyurethane but other polymers such as natural or synthetic rubber may be used.

The particulate material preferably consists of
5 particles in the size range from 0.05mm to 5mm, and most preferably of particles substantially all of which are in the size range from 0.25mm to 5mm. The Moh scale expresses the hardness of materials relative to that of diamond which is given the value 10, and the
10 Moh hardness of a material may be determined approximately by attempting to scratch the surface of the material to be tested with a sample of material of known hardness. The mineral fluorite, or fluorspar, has a Moh hardness of 4 and therefore, in general, any
15 material, the surface of which can not be scratched by a sample of fluorite is suitable for use in our invention.

Suitable materials include minerals such as quartz, zircon, rutile, corundum, topaz and apatite,
20 powdered metals such as iron, chromium, nickel or steel, which is preferably of a rust-resistant type, carbides of metal such as tungsten carbide, or of non-metals such as silicon carbide, nitrides of metals and aluminosilicate materials such as those prepared by
25 calcining kaolin clay at a temperature above about 1100°C.

The wear resistant material may be cast into slabs or tiles for lining, for example, chutes for delivering abrasive material, or may be bonded in the form of a
30 substantially continuous coating onto the inner wall of conduits used for delivering abrasive fluids or as a protective surface for components such as impellers for pumps, attrition grinding mills or froth flotation cells or for the inner wall of grinding vessels or
35 cyclones.

Slabs or tiles may be prepared by a casting

process; for example a polymer forming material and the particulate material may first be mixed together and the mixture then poured into a suitable mould.

Alternatively, if one face only of the slab or tile is
5 to be reinforced, the particulate material may first be distributed substantially evenly over the bottom of the mould and the polymer-forming material poured on top of it. The polymer-forming material should be
10 sufficiently fluid to penetrate into substantially all the voids between the particles and those between the particles and the bottom of the mould. For more complex shapes the technique of compression moulding could be used.

A continuous layer of wear resistant material may
15 be formed by a centrifugal casting process. In the case of lining the inner wall of a pipe the pipe may be heated and rotated rapidly about its longitudinal axis and a quantity of polymer-forming material introduced sufficient to form a substantially continuous layer of
20 polymer. While the polymer forming material is still fluid the required quantity of particulate material is introduced substantially uniformly along the full length of the pipe by suitable conveying means, the rotation of the pipe being maintained throughout the
25 process. Alternatively the polymer-forming material may be introduced into the heated, rotating pipe and allowed to cure for 10-20 minutes. After this time, when the polymer material is relatively firm but still tacky, a mixture of polymer-forming material and
30 particulate material is introduced to form the inner surface of the lining, the rotation of the pipe being continued throughout this process. In this way the particulate material is concentrated near the inner surface of the polymer coating where its abrasion
35 resistant properties are required.

We have found that it is unnecessary to use an

adhesive to bind the particulate material to the polymer. We have, however, found it necessary to dry the particulate material completely, especially when the polymer is polyurethane, because any water associated with the particulate material will react with the isocyanate radicals present in the polymer-forming material.

EXAMPLE I

Sintered alumina of Moh hardness about 8 was crushed and the crushed material screened on sieves having nominal apertures of 1mm and 2.5mm respectively to provide three fractions containing particles of sizes within the following ranges: larger than 2.5mm, from 1mm to 2.5mm and smaller than 1mm.

Each fraction was completely dried in an oven at 70°C for 16 hours and 1000g portions taken from the fractions of dried material were distributed substantially uniformly over the bottom of a steel tile mould of dimensions 300mm x 300mm x 10mm which had been preheated to 70°C and coated on the inside with a silicone-based mould release agent.

Over each portion of crushed alumina in the mould there was then poured a quantity of one of three different polyurethane prepolymers each of which consisted of two components, each component being first melted in a warm air oven at 45-50°C and then degassed under vacuum. The three prepolymers were, respectively, IRATHANE 735, IRATHANE 740 and IRATHANE 2855 ("IRATHANE" is the trade mark of Irathane International Limited). In each case the mixture in the mould was left to harden partially for 30-45 minutes, after which time the tile was removed from the mould and cured under conditions which depended upon the type of prepolymer. The curing conditions for each of the three prepolymers are given in Table I below:-

Table I

Prepolymer	First curing period		Second curing period	
	Temperature (°C)	Time (hours)	Temperature	Time (days)
5 IRATHANE 735	105-110	16	Ambient	7
IRATHANE 740	105-110	16	Ambient	7
IRATHANE 2855	70	3	Ambient	3

Tiles of different compositions were prepared according to the formulations given in Table

10 II below:-

Table II

Prepolymer	Weight of prepolymer per 1000g of alumina (g)		Alumina fraction
15 IRATHANE 735	800		+2.5mm
IRATHANE 2855	820		+2.5mm
IRATHANE 735	920		1.0mm-2.5mm
IRATHANE 2855	800		1.0mm-2.5mm
IRATHANE 2855	710		-1.0mm
20 IRATHANE 740	1000		+2.5mm
IRATHANE 740	740		1.0mm-2.5mm

It was found that no adhesive was required to bind the prepolymer to the alumina.

In each case a tile was formed which had one face
 25 which was reinforced with alumina particles. This face was, in each case, substantially flat and smooth because the prepolymer composition flowed all round the alumina particles and thus the face of the tile which was downwards when the tile was contained in the mould
 30 conformed substantially completely to the smooth, bottom surface of the mould. It was found that a minimum quantity of about 700g of the prepolymer was necessary to cover completely the alumina particles in the mould. In each case the tiles formed as described
 35 above has good wear resistance when used to line a chute for delivering abrasive material.

EXAMPLE II

The apex part of a cone for a hydrocyclone separator was formed as follows:

- 400gms of unfilled polyurethane liquid prepolymer
5 were poured into a mould pre-heated to 70°C and coated on the inside with a silicon based mould release agent and the liquid left for 10 mins to "semi-set".
- 600gms of a mixture of 50% by weight of ceramic
10 grit (1-2.5mm size) and 50% by weight of unfilled polyurethane prepolymer were then added to the "semi-set" polymer in the mould. The mould cavity was then filled with 1.20kg of unfilled polyurethane and the contents of the mould were then allowed to fully set and cure.
- 15 In the resulting product, the ceramic grit was confined to a central region of the apex part, at which the greatest abrasion is known to occur.

CLAIMS

1. A wear resistant material which comprises a mixture of from 20 to 80% by weight of a resiliently deformable polymer and from 80 to 20% by weight of a particulate material of hardness greater than 4 as measured on the Moh scale.
2. A wear resistant material as claimed in claim 1, in which the particulate material is distributed unevenly throughout the material.
3. A wear resistant material as claimed in claim 2, in which the proportion of the particulate material relative to the polymer is greater at a surface region of the material than at an interior region of the material.
4. A wear resistant material as claimed in any one of the preceding claims, which consists substantially entirely of the polymer and the particulate material.
5. A wear resistant material as claimed in any one of the preceding claims, in which the particulate material constitutes not less than 40% by weight of the material.
6. A wear resistant material as claimed in any one of the preceding claims, in which the particulate material constitutes not less than 40% and not more than 60% by weight of the material, at least at a surface region of the material.
7. A wear resistant material as claimed in any one of the preceding claims, in which the polymer is polyurethane.
8. A wear resistant material as claimed in any one of claims 1 to 6, in which the polymer is natural or synthetic rubber.
9. A wear resistant material as claimed in any one of the preceding claims, in which the particulate material comprises particles in the size range from

0.05 mm to 5 mm.

10. A wear resistant material as claimed in claim 9, in which the particulate material comprises particles in the size range from 0.25 mm to 5 mm.

5 11. A wear resistant material as claimed in any one of the preceding claims, in which the particulate material comprises a mineral.

10 12. A wear resistant material as claimed in claim 11, in which the particulate material comprises quartz, zircon, rutile, corundum, topaz or apatite.

13. A wear resistant material as claimed in any one of the preceding claims, in which the particulate material comprises a powdered metal.

15 14. A wear resistant material as claimed in claim 13, in which the particulate material comprises powdered iron, chromium nickel or steel.

20 15. A wear resistant material as claimed in any one of the preceding claims, in which the particulate material comprises a carbide or a nitride of a metal or of a non-metal.

16. A wear resistant material as claimed in claim 15, in which the particulate material comprises tungsten carbide or silicon carbide.

25 17. A wear resistant material as claimed in any one of the preceding claims, in which the particulate material comprises an aluminosilicate.

18. A wear resistant material as claimed in claim 17, in which the particulate material is prepared by calcining kaolin clay at a temperature above 1100°C.

30 19. A wear resistant material as claimed in any one of the preceding claims, which is in the form of a cast slab.

20. A wear resistant material substantially as described herein with reference to the Examples.

35 21. A wear resistant article comprising a wear resistant material in accordance with any one of the

preceding claims.